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PAMC Based IEEE 1451 Wireless Sensor Interface Plug And Play Mechanism and Implementation

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Abstract

Aims at ZigBee wireless intelligent sensor that complies with IEEE 1451.5, an implementation method based on periodic association matching communication (PAMC) is put forward in order to realize wireless sensor interface plug and play. Four kinds of communication message frame format are defined at ZigBee application support sublayer, and the contents of transducer electronic data sheet (TEDS) are redefined according to actual application. Both network capable application processor (NCAP) and wireless transducer interface module (WTIM) start protocol stack event handling process to monitoring network structure change, and data storage units are used to real-time update, save the network structure parameters. An association configuration table is defined in NCAP to preserve WTIM transducer channel information. Through the association request frames periodically send by WTIM, NCAP can quickly and accurately identify WTIM access, disconnect network. Set up a ZigBee intelligent sensor system test platform, test show that using PAMC method can effectively implement IEEE 1541 wireless sensor interface plug and play and identification; Set association matching communication period to 1 second, WTIM network access time is less than 1.8 seconds, better meets the practical application requirements.

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Keywords: IEEE 1451; PAMC; plug and play; Zigbee

1. Introduction

Wireless sensor networks are widely applied in industrial control, intelligent household, health care, military monitoring, etc. The introduction of networkization and intelligentization greatly enrich wireless sensor types, and system configuration become more complicated^[1]. According to statistics, measurement

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engineers revealed that nearly 20% of the total cost of most data acquisition applications is spent on hardware/sensor set up and configuration. Plug and play intelligent sensors not only shorten the software and hardware builds time, but also increase the overall system integration and reliability. Access, failure and damage of wireless intelligent sensor lead to structure changes, and wireless sensor network must adjust and organize timely, which requires the wireless intelligent sensor of extendibility, standardized interfaces and plug and play ability. Therefore, ensure wireless intelligent sensor plug and play is one of the key problems that wireless sensor networks need to solve, relevant research has great significance^[2].

IEEE 1451.5 standard makes wireless intelligent sensors capable of interchangeability and interoperability in different wireless networks, and also provides an effective solution for the standardization and expansibility of wireless intelligent sensors^[3]. Zhang Yunwei(2007) present a routing design based on IEEE 1451.5 standard, makes the communication between NCAP and multi-STIM more generalized^[4]; Higuera J(2009) present an implementation of IEEE 1451.5 wireless sensor network, and enhance ZigBee message structure and PHY TEDS to improve the interoperability^[5]; Song E Y(2010) develop a test system to verify the interoperability between NCAP and WTIM based on IEEE 1451.5-802.11 standard^[6]; Lee M(2010) proposes a home healthcare monitoring system data exchange scheme between HL7 devices and IEEE1451 wireless sensors^[7].

The wireless sensor network usually adopts different frequencies channel or different physical address to separate and identify different sensors, but limited available address range or frequency channel scope restricts network scalability. IEEE 1451.5 standard defines wireless intelligent sensor software and hardware structure of WTIM and NCAP, and never provide concrete realization method of plug and play. Therefore, this paper put forward a PAMC method to achieve plug and play function of wireless sensor interface between NCAP and WTIM.

2. PAMC based wireless sensor interface plug and play mechanism

Wireless sensor system based on IEEE 1451.5-ZigBee mainly constituted by NCAP, WTIM and end users. A WTIM may consist of several channels, realizes data collection and information acquirement, and transfer data to NCAP. NCAP will summarize, storage, processing, and analysis the received data, communicates with end users through the user network. The system structure is shown in Fig. 1(a).

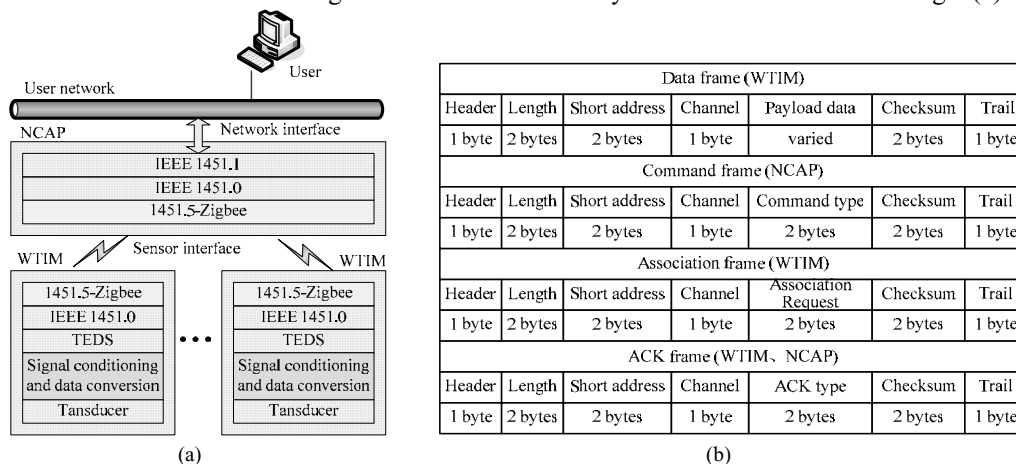


Fig. 1 IEEE1451.5 wireless sensor system and MSG frame. (a) System diagram; (b) PAMC MSG frame format.

ZigBee application layer message service type (MSG) content can be redefined according to actual application needs. Four kinds of frame structures are defined in MSG message, as shown in Fig. 1(b).

An association configuration table is established in NCAP data storage unit, which includes WTIM short address, channel number, channel TEDS length and storage address of channel TEDS information.

When transducer channel is measuring parameter, each data frame WTIM transmit to NCAP contains short address, channel number. NCAP can judge accordingly that WTIM and transducer channel are both working within network. Under idle circumstance, no data frame transmission between NCAP and WTIM, WTIM initiative send an association frame to NCAP regularly, from the short address and channel number of associated frame, NCAP judge that WTIM and transducer channel are still within network. After schedule time, if NCAP still have not received WTIM timing association frame, it implies WTIM has disconnected from network. If WTIM has not access network for a long time, NCAP will automatically remove the WTIM information in association configuration table.

If WTIM reengage the network within schedule time after its disconnection, NCAP will find the matching information of WTIM in association configuration table. It does not need to performed read WTIM TEDS operation, WTIM and transducer channel configuration can be completed by directly using the available WTIM information in association configuration table.

3. PAMC based wireless sensor interface plug and play implementation

NCAP starts wireless network using coordinator mode, initializes wireless communication protocol stack, select a network number as personal area network identification (PAN ID), choose a wireless transmission frequency channel through energy scanning. and open to WTIM access request. WTIM undertakes frequency scanning, and sends beacon request to NCAP. NCAP responds corresponding PAN ID to WTIM to identify itself. After WTIM detect PAN ID, it will send join application to NCAP; If accept WTIM application, then NCAP will allocated a 16 bit short address to WTIM, used as its network identification. NCAP and WTIM start protocol stack event handling process, save network parameters while network structure changes, and WTIM sends association frame to NCAP regularly.

When there appears at least a WTIM in network, NCAP can implement data transmission with WTIM. NCAP send upload TEDS command to WTIM, after get WTIM sensor information, and then send WTIM a configuration transducer channels command, enable WTIM transducer channel work at a right measurement mode. The workflow diagram of WTIM is shown in Fig. 2.

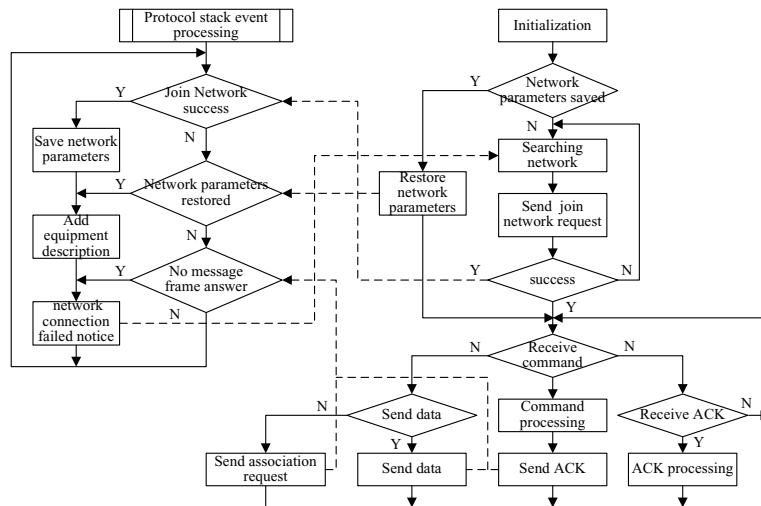


Fig. 2. WTIM workflow diagram

IEEE 1451 defines TEDS more multifariously, PAMC simplifies the TEDS definition to store wireless sensor attribute information, and according to the actual application redefined the Meta TEDS, Channel TEDS, PHY TEDS content. By loading TEDS, NCAP can obtain various physical characteristics and information of sensors, complete sensors configuration and realize plug and play. The operation sequence of TEDS data transfer and sensor configuration between NCAP and WTIM is shown in Fig. 3.

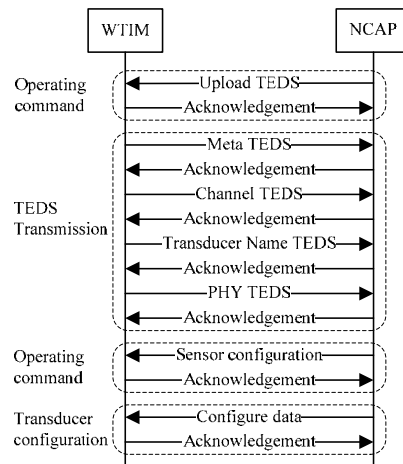


Fig. 3. TEDS operation sequence chart

4. Application example

A ZigBee based IEEE 1451.5 intelligent sensor system is shown in Fig. 4 PC is used as virtual NCAP, and connects an external wireless micro controller module JN5139 as ZigBee network coordinator. Simultaneously, weighing sensor, proximity sensor, inclination sensor, light sensor temperature and humidity sensor are developed, which are used as five kinds of WTIM. WTIM test data are transmitted to virtual NCAP for concentrate display and management. NCAP provides web service via PC's network interface, and releases these test data on user network, which can be accessed by remote users.

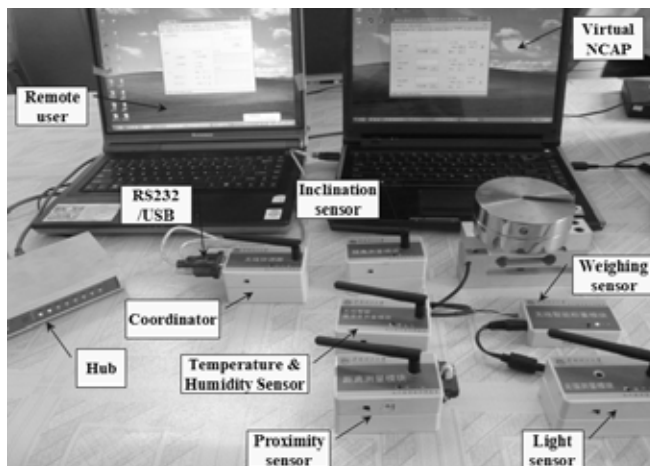


Fig. 4. ZigBee intelligent sensor system based on IEEE 1451.5

Table 1. WTIM recognition time of different distance

Distance (m)	1	10	20	50	100
access time (s)	1.21	1.24	1.38	1.52	1.64
Disconnect time (s)	3.12	3.14	3.26	3.45	3.55

Set WTIM association matching communication period to 1 second, and disconnect network limit time to 3 seconds, using the aforementioned test platform, WTIM access and disconnect time of NCAP network are test under different distance. Test results are shown in table 1. It can be seen that PAMC based IEEE 1541 wireless sensor interface can identify the access and disconnection of WTIM timely, and satisfies the requirements of practical application.

5. Conclusion

(1)IEEE 1451.5 greatly simplifies the complexity of wireless intelligent sensor configuration and access, and further improves the wireless sensor interface properties and adaptability;

(2)PAMC based IEEE 1451 wireless sensor interface plug and play mechanism not only identify WTIM access and disconnection effectively, but also realize transducer channels fault detection of a multi-channel WTIM, improve the sensors system efficiency and reliability;

(3)Application of PAMC method can flexible construct wireless intelligent sensor system, this plug and play method is also suitable for wireless interface of other types sensors and equipments, and provides a flexible and efficient way to realize networked measurement and control.

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References

- [1] Sun Shenghe. Development trend of modern sensor. *Journal of Electronic Measurement and Instrument*, 2009; 23(1):1-10.
- [2] Wynn Ryan. The sensors plug and play revolution has begun. *IEEE Computing and Control Engineering*, 2005; 16(1):20-22.
- [3] Nemeth-johannes Jay, Sweetser Victoria, Sweetser David. Implementation of an IEEE-1451.0/1451.5 compliant wireless sensor module. *42nd Annual IEEE AUTOTESTCON Conference*, 2007: 364-371.
- [4] Zhang Yunwei, Xie Yongping, Yang Zhijia. Routing design for wireless sensor networks based on IEEE 1451 standards. *Chinese Journal of Scientific Instrument*, 2007; 28(4):746-747.
- [5] Higuera J, Polo J, Gasulla M. A ZigBee wireless sensor network compliant with the IEEE1451 standard. *2009 IEEE Sensors Applications Symposium*, 2009:279-283.
- [6] Song E Y, Lee K B. An interoperability test system for IEEE 1451.5-802.11 standard. *2010 IEEE Sensors Applications Symposium*, 2010:183-188.
- [7] Lee M, Gattton T M. Wireless health data exchange for home healthcare monitoring systems. *SENSORS*, 2010; 10(4): 3243-3260.